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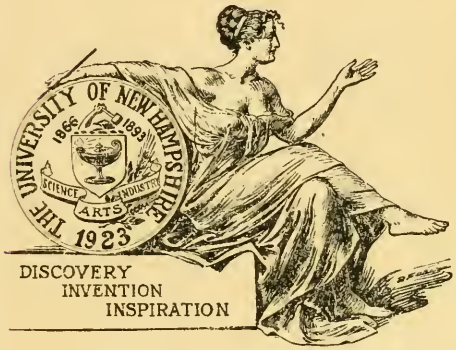

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STUDIES IN TERMITE CONTROL

By W. C. O'KANE and W. A. OSGOOD

NEW HAMPSHIRE COLLEGE
OF
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DURHAM, N. H.

STUDIES IN TERMITE CONTROL

By W. C. O'Kane and W. A. Osgood.

Summary

Termites are a destructive group of insects which attack and seriously damage beams, timbers, flooring, partitions and various products made of vegetable fibre.

The infestation here described took place in a modern hospital in a New Hampshire city and involved extensive damage to partitions, floors, beams and other woodwork.

A large amount of infested material was removed and destroyed. Tile and cement were substituted.

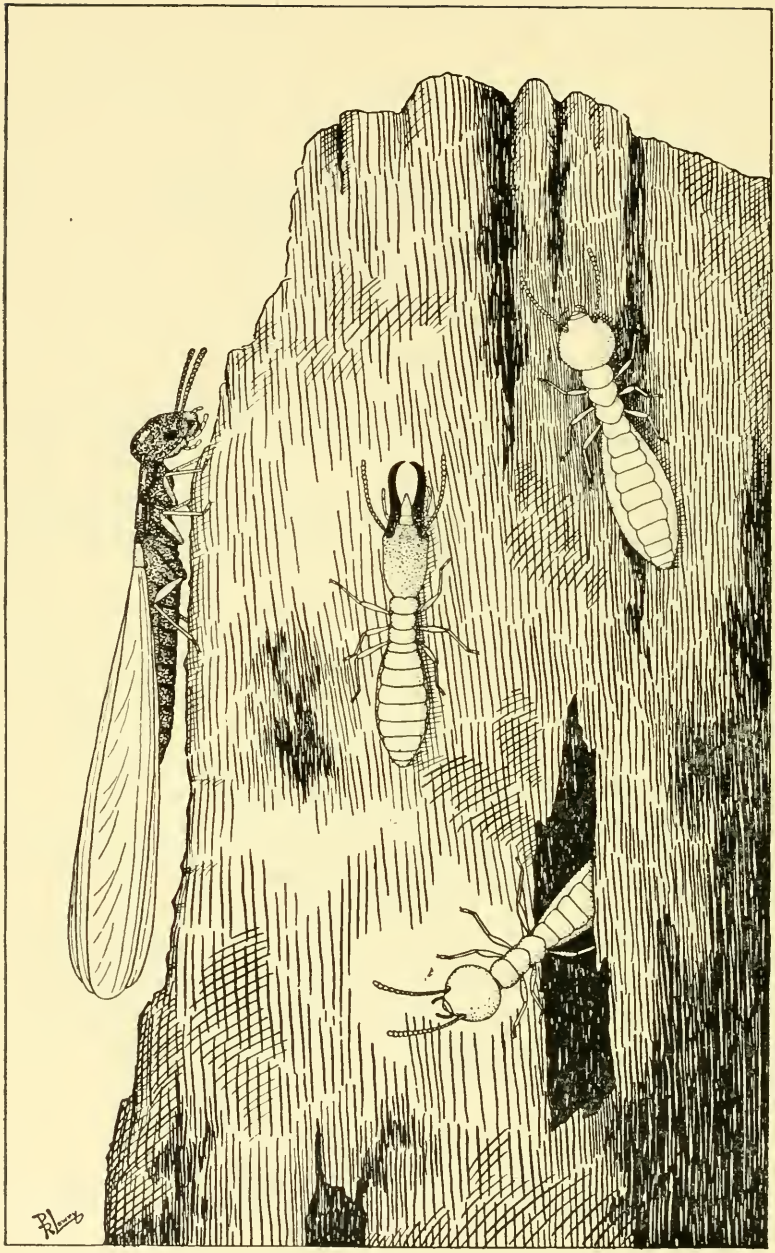
Preliminary experiments were arranged to determine the time and temperature factors necessary to kill termites in wooden beams by heat.

Supplementary steam piping was installed in the basement and the temperature was raised to 135° for 24 hours.

No living termites have since been discovered within the building.

The structure remained in undisturbed use for hospital purposes while the heat treatment was going on.

Extensive infestation was found through much of the hospital grounds. Board traps were utilized to discover the extent of this infestation. Timbers, board walk, apple trees, etc. were removed. A mixture of Phinotas oil and water at a dilution of one-half of one percent was used to kill termites in the ground and to render the ground unacceptable to them.



TERMITES AT WORK

(Enlarged to Ten Times Natural Size)

At the left is a winged migrant. In the center is a soldier with strong jaws for fighting. At the right is a worker. Emerging from a burrow is another worker.

Introduction.

Termites are a destructive group of insects which attack beams, foundation timbers, flooring, wood partitions and in fact all sorts of wood products to which they can gain access. They have a record of serious damage at various points in New Hampshire, and their work is of such a nature that in the majority of cases it is not discovered until a building is moved or torn down, or until repairs are instituted. Even then the damage is frequently ascribed to "dry rot."

In the tropics there are many species of termites but in New Hampshire, so far as is known, only one species is found, *Leucotermes flavipes* Koller. In the southern half of New Hampshire this insect is known to have caused serious damage in public buildings, farm houses, barns and other structures.

A familiar name for termites is "white ants." They are not really ants but they resemble them strongly in their superficial characters and, in addition, they have a community life which is similar in many respects to those of some of our common species of true ants.

Unlike ants, however, the great majority of termites are white in color, are sensitive to light, which they shun, and are blind. They live in colonies and within each colony there are various castes or specialized groups adapted for particular duties. The largest number of individuals in a colony are the workers. These are either male or female, but are undeveloped or immature sexually and remain so throughout their life. Within each colony there will be found, also, a considerable number of individuals, each with an elongated head armed with a pair of long jaws shaped like cutlasses. These individuals are known as "soldiers" and are supposed to serve as protectors of the colony. Also within a colony will be found one pair or more of mature kings and queens and frequently various additional or supplementary queens.

Life in the colony is complicated, as with other highly specialized, social insects. The workers forage for food, which they find by traveling sometimes to a distance of many yards in underground galleries. They always work concealed. Timbers will be hollowed out inside, but a thin outer shell will always be left untouched. To outward appearances a beam that is completely destroyed inside may look to be quite sound. Sometimes colonies will cover a considerable area, amounting to many square yards. Usually it is very difficult to find out where the center or centers of the colony may be located. When compelled to cross a space into which they cannot burrow, as for instance a concrete wall, termites will build a gallery, or enclosed runway, within which they travel back and forth in darkness and security.

Outside of heated buildings the activities of termites cease during cold weather. Thus, a colony located in a stump or within rotted wood in the heart of an old apple tree may become totally inactive during cold weather. But within heated buildings activity may go on continuously.

Once a year, probably in June in the latitude of southern New Hampshire, there is a flight of specially developed winged termites. These individuals are brown in color, are not sensitive to light and have functioning eyes as

well as wings. They emerge suddenly in large numbers from the colony and include both males and females. After flying a few yards or, at most, a few rods, they alight and such pairs as survive the flight settle down to found new colonies. The wings are promptly broken off near the body. This annual flight serves to spread the species, to avoid overcrowding and to found new colony groups.

Studies in Termite Control.

The data presented in this publication are concerned in general with the measures adopted to eradicate termites from an occupied public building in New Hampshire and to protect the building from further infestation, and in particular with the use of heat as a means of killing termites within timbers and floors.

The building in which the infestation was discovered is a modern hospital located in one of the cities of New Hampshire. The structure is divided into three principal parts: a central portion, a wing to right and another to left. The wings are connected to the central portion by corridors. The outer walls are built of stone and brick. Some inner walls, as indicated on the plans, are of brick. Most of the inner partitions, however, are wood studding, plastered.

The central portion of the structure is used in part for administration purposes. On the first floor are an office, waiting room, matron's room, doctors' room and a service wing. Above these are private rooms for patients. The basement of this part of the structure is fitted up for store rooms, laundry and boiler room.

Corridors forty feet long connect the administration building with the men's pavilion to the south and the women's pavilion to the north. These corridors have brick walls and at the place where each corridor enters the administration building, as well as the place where it enters the pavilion, there is a brick cross-wall with a fire door. The two pavilions are sub-divided into wards and private rooms, the partitions being of wood.

The hospital is located on a large plot of ground at the edge of the city in question. It has ample space of lawns all about it. There are some trees. South of the building there was situated, at the time that these studies began, a frame house and the remnants of a frame barn, both of them built many years ago.

The hospital is maintained in scrupulous order and every measure is adopted for hygienic cleanliness that may be found in any well-regulated institution of its purpose. Both the buildings and the equipment are modern and complete.

In the spring of 1917 a number of insects, which undoubtedly must have been winged termites, were observed by the hospital officers emerging from a crack under a door-sill in the opening leading from the corridor of the administration building into a room that was, at that time, used as a dispensary,

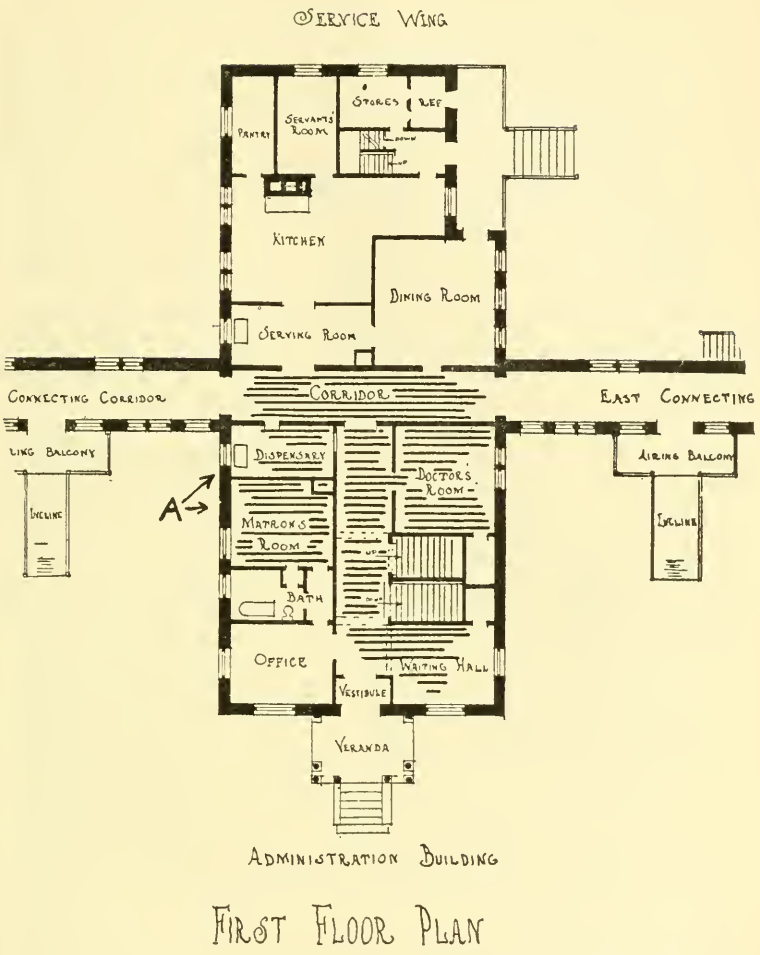


FIG. 1. Plan of the first floor of the administration building. The infestation on this floor extended through the area shaded in horizontal lines.

but has since been made a part of the matron's room. (Fig. 1, A). The emergence lasted for only a short time. While it caused anxiety to the hospital staff, nothing further was seen of the insects on that occasion and it was supposed that they were no longer present.

In the winter of 1918 their work was discovered in serious degree. At that time articles were being moved from one of the shelves in a store room in the basement of the administration building (Fig. 2, A.B.). As this task was in progress the partition to which the shelving was attached gave way. Some of the lath and plaster were removed, and it was found that the studding had been practically destroyed. The writers of this bulletin were then called into consultation and the work of eradication and control began.

The species of termite concerned proved to be the form commonly found in the central and northern states, *Leucotermes flavipes* Koller.

Workmen employed by the hospital began tearing out the basement partitions. As this job proceeded, more and more evidence of the extensive mining that had been accomplished by the termites was laid bare. Practically all of the partitions in the main part of the basement of the administration building had been attacked. (Fig. 2, A. B. C. D. E. F. G. H.). A brick partition separated this part of the basement from the boiler room. (Fig. 2, I.) But in the boiler room planks used to enclose a coal bin were found infested. The supports of two stairways, leading into the basement (Fig. 2, F. H.), had been attacked.

In the basement floor there are several hand holes, where turns occur in drain pipes and the like, located beneath the floor. These hand holes had wooden linings and in each case this wood was thoroughly infested.

The floor of the basement was cement. But the various wooden partitions had been built before the cement was poured. Therefore, the studding of the partitions was in direct contact with the sandy soil which underlies the basement. This may have furnished the means of entry by which the termites got into the basement, but of this no certain statement can be made. The basement floor is at a depth of four or more feet below the level of the ground outside. It may be that the termites burrowed beneath the basement wall and the cement floor and came up into the partitions, or it may be that they found access through some crack in the foundation walls where a partition was close by. In any event they had fairly riddled most of the partitions in this basement.

As the wood partitions were removed it was discovered that the insects had burrowed into some of the wood beams that support the floor timbers and the structure above. These wood beams rest on brick pillars. They are 10 x 12 inch timbers and for the most part are 18 feet in length. Two of these timbers had been so hollowed out by termites that they were structurally worthless.

In addition, it was discovered that the lower layer of the double flooring of the first or main floor of this building had been attacked. This lower layer is made up of soft wood boards. Above these is a hardwood flooring.

This led the search to the first or main floor where parts of the hardwood flooring were torn up in order to discover to what extent the boards under-

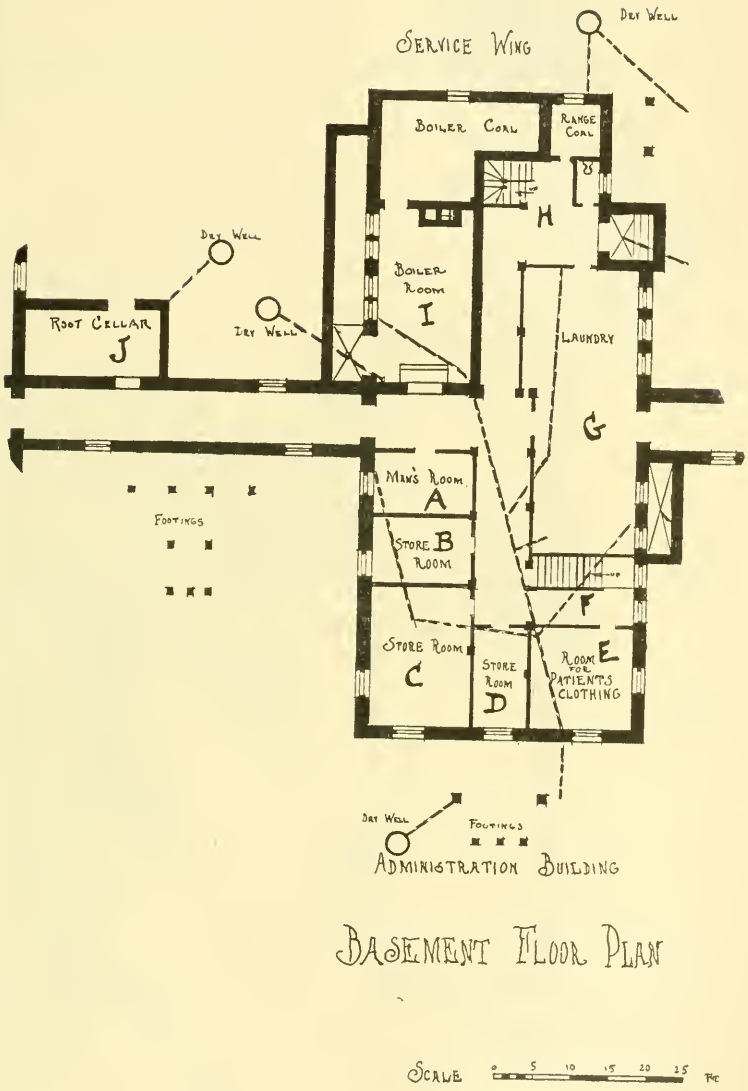


FIG. 2. Basement plan of administration building showing the partitions as they were at the time the infestation was discovered.

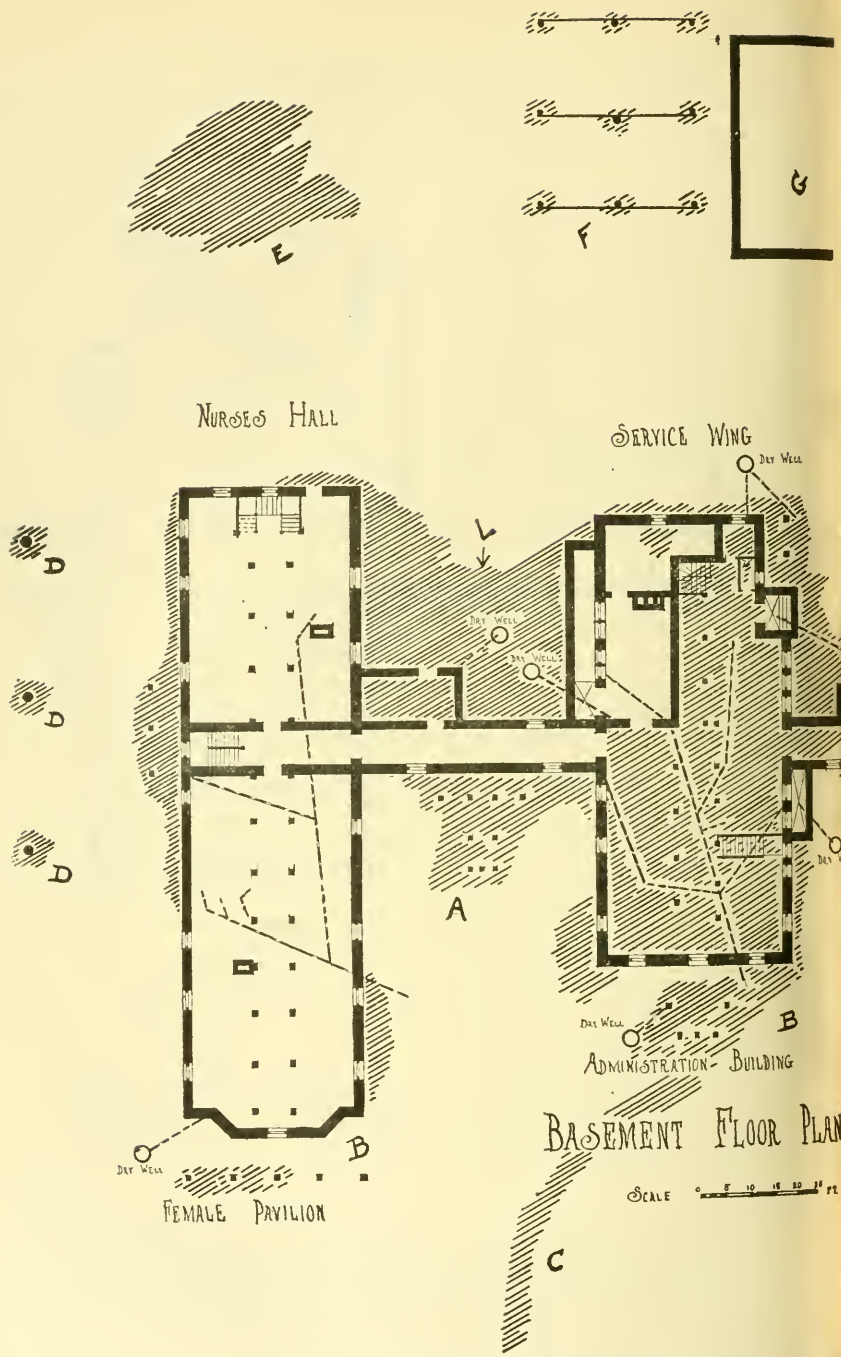
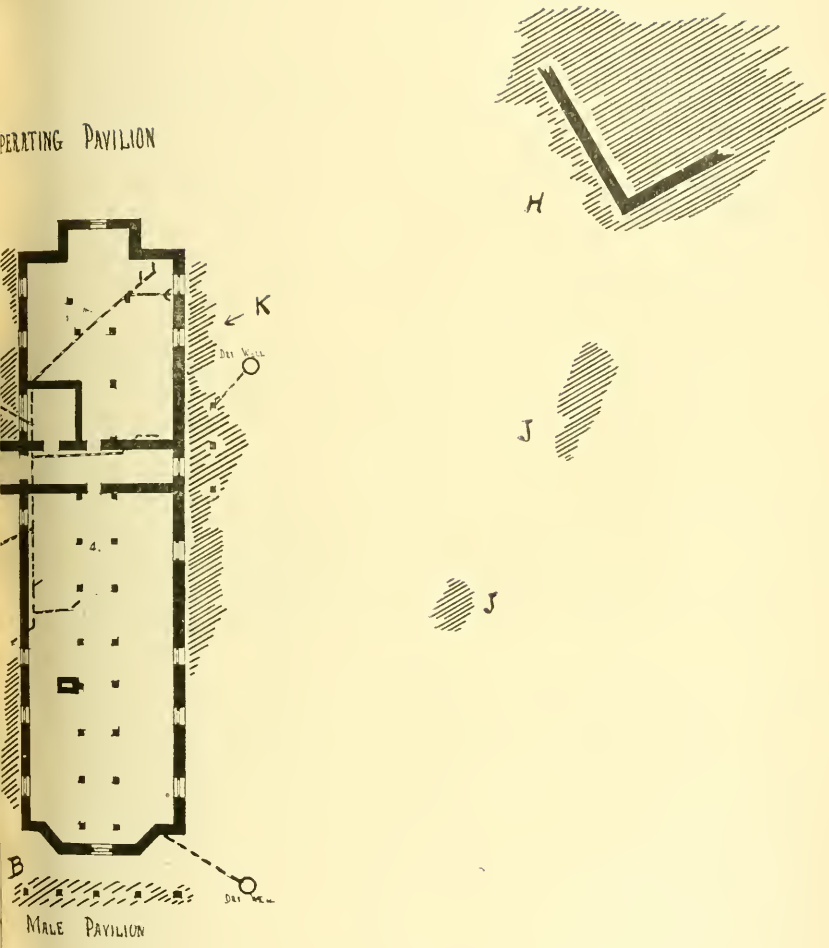


Fig. 3. General plan of the hospital buildings and surroundin



were found through all of the area shaded in diagonal lines.

neath had become infested. Baseboards along the partitions of this floor were removed so as to ascertain whether the insects had extended their work into the partitions above. In order to determine this a section 6 inches long was sawed out of every other upright of these partitions, next to the floor. These sections gave uniform evidence that the work of the termites had ceased at about the floor level. Apparently, they had not yet had time to extend their ravages into the first floor partitions.

The task of eradication of the insects from the administration building now began.

All of the partitions and other material that had been taken out of the basement and first floor were burned. The spaces that were left in the concrete basement floor where the partitions had projected through to the ground beneath, were filled with cement so that the entire basement presented a continuous floor of concrete extending to the outer walls. The linings of hand holes were removed and burned.

Stairways were taken apart, or the lath and plaster removed far enough to disclose the upper limits to which the termites had mined. They were reconstructed so as to rest on the concrete floor. The infested boards in the boiler room were removed and burned.

It was necessary to remove two of the main supporting beams. In order to do this the central part of the building was supported with temporary timbers; the large beams—or what was left of them—were taken down from the brick pillars; and new beams were got into position by placing planks side by side vertically and bolting these together.

There was no way of making really certain that all material carrying termites had been removed. On the contrary, it was more than likely that some of the flooring and other wooden parts still held large numbers of the insect. It will be noted that the laundry for the hospital was located in this basement. Both as to heat and moisture this furnished conditions well suited to the further increase of the pest, if living specimens remained within the building.

In this emergency it was decided to attempt extermination of any termites remaining in the basement by means of heat.

Experiments were first carried out to determine the time and temperature factors that would be required for killing the pests within timbers. It was necessary not only to know what temperature would be required and for how long a period where the termites were more or less directly exposed to the heat, but also to determine what factor should be taken into account in order to make certain that killing would take place within heavy supporting beams, since there was serious probability that beams that had not been removed contained numbers of the termites.

Blocks of spruce wood 10 x 10 x 10 were prepared. Each block was sawed in half and bolts arranged so that the two halves could be rejoined securely. The surface of the two halves, where they were joined, was planed. A square of asbestos measuring 10 in. each way and 1-4 in. thick was fitted between the two halves. At the center of the asbestos a hole was cut, measuring 1 in. square. When the two halves were joined, with the asbestos board between

this provided a small cell 1 in. square and 1-4 in. deep in the center of the block.

In the experiments, ten termites were placed in the cell in each test. The halves were then bolted together and the block was placed in a Freas electric oven provided with thermostat control. The block was allowed to remain in the oven for 24 hours at various temperatures, ranging from 155° F. down to 95° F. The tests were started at a temperature of 155° F. and in successive tests this was dropped until a point was reached at which the termites were not killed. It was found that a temperature of 120° F. continued for 24 hours, resulted in the death of all of the termites in three tests, but a temperature of 95° F., continued for 28 hours failed to kill them. The detailed results are given in the following table:

TEMPERATURE TESTS

Killing Effects of Heat on Termites Placed in Center of Spruce Block
10x10x10

No. of Insects	*Temperature*	*Time*	*Results*
10	155°F	24 hrs.	All dead
10	155°	24	" "
10	145°	24	" "
10	145°	22	" "
10	135°	24	" "
10	130°	24	" "
10	130°	24	" "
10	125°	24	" "
10	120°	24	" "
10	120°	24	" "
10	120°	24	" "
10	95°	28	2 dead, 8 alive

Following these preliminary tests, arrangements were made for installing supplementary steam pipes in the basement, of sufficient capacity to raise the temperature within the entire basement to 130° F. or more and to maintain it there.

In the rear of the basement was a small boiler capable of carrying a steam pressure of 50 lbs. or more, (Fig. 4, A.). A system of pipes was installed connecting with this boiler. Two inch pipes were used, arranged in three horizontal sections of seven pipes each. The pipes were supported on temporary brackets about 18 in. below the basement ceiling. They were arranged with only sufficient slope to drain off condensation. Each section extended the length of that part of the basement in which it was placed. The general arrangement of the system is shown in Fig. 4. The total amount of radiation surface was 700 feet, or about one foot to each 20 cubic feet of space in the basement.

A preliminary test was made and the system was found to be in good working order. The following day, at 6.00 p. m., steam was let into the pipes at a pressure of 40 lbs. Before the steam was turned on, all cracks in windows and doors were sealed with paper. The temperature in the basement just before steam was admitted was 80°. The date was March 22 and the tem-

perature outdoors was that of moderate spring weather.

A thermograph was placed in the basement about two-thirds of the distance from the boiler room to the front wall and about 6 feet above the basement floor. It was located midway between two of the banks of steam pipes but not immediately adjacent to them. Close beside the thermograph was set a block of spruce wood 8 x 8 x 8 containing eight living termites in a small cell in the center. The thermograph and the spruce block with its termites were left in this position for the next 24 hours.

At five points in the floor above a half-inch hole was bored and a thermometer, run through a cork, was lowered through each hole. Readings were recorded from these thermometers every hour during the following 24 hours.

The remainder of the building continued in use throughout the treatment. The administration offices served their usual purpose. Patients remained in their rooms above without knowledge of the treatment going on in the basement.

Within an hour after the heat was turned on the temperature began to rise, and this rise soon became rapid. By 9.30, or 3 1-2 hours after steam was admitted, the temperature in the upper part of the basement area had reached 120° F. Two hours later it had risen 15° further to 135° F. About six o'clock the following morning it was necessary to shut off steam, in order to make a slight repair to the boiler. The temperature in the basement promptly dropped to about 120° F. in the next 45 minutes, but when steam was turned on it rose fairly rapidly again and by ten o'clock had regained the high point of the earlier hours. At 4.00 p. m. the temperature began to rise still further and when heat was finally turned off at 6.00 p. m., 24 hours after the treatment started, the temperature had reached 140° F.

The readings of the five thermometers were averaged and have been reduced to a curve indicated by the dash line A in Fig. 5. The readings of the thermograph are indicated in the dotted line B of Fig. 5. It will be noted that the curve A runs higher than B, but it will be recalled that the thermometers from which the record A is taken were nearer to the basement ceiling than was the thermograph.

When the treatment was concluded, the spruce block containing 8 termites was opened and all were found to be dead. In addition, they were somewhat brown and brittle, as if they had literally been baked.

After the heat treatment had been finished, the task of replacing and repairing damaged woodwork on the main floor was carried out. Much of the flooring had been taken up in searching for the termites and, as already related, much of the studding had been cut off at the lower part. This work was now carried further and flooring was replaced or renewed over a considerable part of several rooms. In doing this the workmen took up and removed many boards containing termite galleries and in a number of these there were termites present. But all termites found were dead. No living termite was found within this building in any subsequent work.

In the basement new partitions were erected, built of tiling. As already explained, the entire basement floor had been fully cemented. The walls of

the basement were carefully examined for possible cracks and throughout the entire season a close watch was kept for any possible entry of termites through the walls. In no case were they discovered. The areas on the first floor where flooring was removed and replaced are indicated by the shaded portion shown in Fig. 1.

Meanwhile, and for a long time afterward, work was in progress outside the hospital building to discover termites and to try to get rid of them. The surroundings of the building are shown in Fig. 3. The shaded parts indicate areas in which termites were found. It will be noted that there was a very general, widespread and serious infestation.

To right and left of the administration building there is an incline leading up to the corridors that connect the pavilions with the administration building. (Fig. 3, A. A.). That part of these entrances which was near the ground was found to be infested. The lower part, therefore, was removed as far as the infestation had proceeded. A concrete foundation for the incline was built in each case.

On the front of the administration building and on the front of both pavilions there are porches (Fig. 3, B. B.). Beneath the floor of these porches was lattice work, extending in some places to the ground. A considerable part of this was infested. The lower part of the lattice was sawed off so that there would be a clearance of 6 inches between the ground and any lattice.

At the rear of the administration building, also, there is a porch and at the rear of the corridor leading to the men's pavilion there is an outside wooden stairway. Many termites were found in the neighborhood of this rear porch and the stairway was badly tunneled. Termites had gained access to the stairway through cracks in brick piers on which the posts supporting the stairway were placed. Posts and infested parts of the stairway were removed and the structure rendered termite-proof.

In the front of the administration building a narrow board walk followed the entrance driveway in a curving line to the street. On lifting this board walk many termites were found beneath. The entire board walk was removed and destroyed. (Fig. 3, C.)

Just north of the women's pavilion were three old apple trees (Fig. 3, D, D, D). These appeared to be vigorous but had some hollows and some dead wood within the trunks and larger limbs. They were discovered to be thoroughly infested. All three trees were removed. The earth was dug away from around the roots and these were pulled out and destroyed, along with the rest of the trees.

At the rear of the women's pavilion and located 60 feet from it was a low mound of earth containing various bits of board. Termites were discovered here and this material was burned. (Fig. 3, E.)

At the rear of the administration building and about 70 feet away were sets of posts supporting clothes-lines. Termites were discovered here, also. These posts were removed and in their place new posts were set which had been treated with creosote and which were now imbedded in cement piers (Fig. 3, F.)

Immediately adjacent to these posts is a structure open on one side, used

for temporary storage of doctors' automobiles. While this structure is of wood, it rests on a cement foundation. No termites were discovered in any part of it (Fig. 3, G.).

South of the men's pavilion and distant about 75 feet were the remains of an old frame barn, including the cellar, old foundation stones and some large timbers lying on the ground. (Fig. 3, H.) Large numbers of termites were discovered here. Some of the old timbers were infested and these were destroyed. Repeated search disclosed numerous termites on turning over stones. These were destroyed by the use of hot water and later by the use of a mixture of Phinotas oil and water, as will be described later. Southwest of this barn and still farther away from the hospital buildings was a frame house (not shown in Fig. 3). There was some evidence of termite work in the lower part of the house. Later, this building was moved away from the premises.

Between the frame dwelling and the hospital building were the stumps of two or three trees that had been cut off close to the ground and graded over. These were uncovered and were found infested. They were dug out as much as possible and were treated in the same fashion as the earth beneath the stones of the barn. Also, some buried pieces of boards were found in this general area where they had been covered by grading. These were treated in similar manner, (Fig. 3, J. J.)

Toward the rear of the men's pavilion a small hotbed about 4 feet square had been built, immediately in front of one of the basement windows. (Fig. 3,K). This was found to be riddled. Large numbers of termites were discovered in the dry manure remaining within the hotbed. All of this was removed and destroyed.

In the rear of the basement corridor leading from the administration building to the women's pavilion a root cellar had been constructed two or three years before. The walls were of cement and brick and the floor of cement. There were no outer windows. (Fig. 3, L; Fig. 2, J.) The insects had gained entrance through cracks in the cement floor. From the point of entrance they had constructed covered galleries over the floor and wall to a distance of several feet. The root cellar received a two-fold treatment. First, it was fumigated with carbon bisulphide, which was poured into the cracks in the cement, the building being kept tightly closed for a day or two. Following this the cracks were sealed by filling them with hot tar. This was used in order to have a somewhat flexible material that presumably would not open up, allowing further entrance of the pest. Since this was done, no termites have been discovered in the root cellar, although for a long period thereafter there were large numbers of them constantly disclosed under trap boards placed in the adjacent area outside.

Because of the large numbers of termites that were discovered through much of the surroundings of the building it was felt that a good deal of danger existed that the pest might again find entrance. With the intent of reducing this danger or perhaps obviating it, the earth next to the foundation wall and to a depth of about 3 feet was removed all around the outer walls of the entire structure. This made a trench about 12 in. to 18 in. wide. The

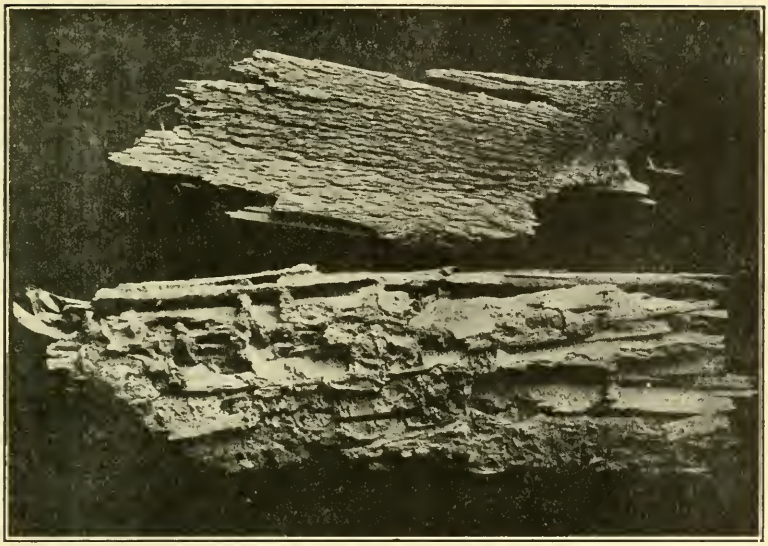


Plate 1, A. At the top is a small section of a beam, showing surface apparently sound and giving no indication of the damage beneath. The lower piece shows galleries filled with frass.

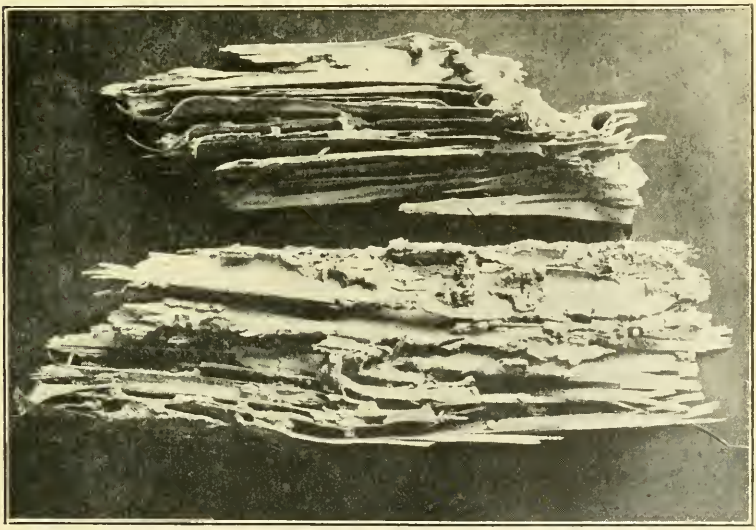


Plate 1, B. Upper piece is the same section of wood as that shown at the top of Plate 1, A, but is the reversed side. Lower piece is the reverse of the lower one shown in Plate 1, A.

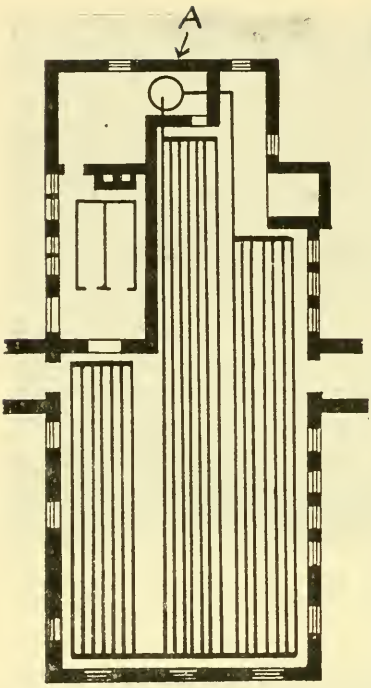


FIG. 4. Diagrammatic plan of supplementary heating coils installed in basement of administration building.

earth, as it was removed, was treated with Phinotas oil and water and carted away to a dump.

In this work, and in the treatment of termites found under stones at the old barn cellar and in similar places, Phinotas oil was used because it mixes promptly with water and has strong insecticidal properties. It is easily prepared for use simply by pouring the oil into water. Water was used in such amount as to give a dilution of one-half of one percent. It was found that this dilution readily killed termites. So far as experience in this place is concerned, the ground so treated remains unsuitable to termites for a considerable or perhaps an indefinite period thereafter.

The trench next to the foundation walls was filled with cinders. The intent of this was to provide next to the walls a band of material which presumably the termites would find less suitable than earth containing organic matter. It was expected, also, that the cinders would remain rather dry throughout the season when the termites were most active and, therefore, would offer a medium not well adapted to their galleries. The bottom of the trench was treated with Phinotas oil and water before the cinders were placed in it. Up to the present time no further evidence of termites has been discovered in the trench or in or on the foundation walls, although throughout the two seasons that have followed many termites have been found short distances away.

It was thought that the work of fighting the pests in the grounds outside the building would be facilitated if it were possible to discover the source or sources from which they were working toward the building. In order to attempt this, small blocks of pine wood, four of five inches square, were placed on the ground, every three or four feet all the way around the entire circumference of the building, two or three feet away from it. These blocks were turned over and examined every two or three days. The result of this was the disclosure that by far the greater part of the entire area surrounding the building appeared to be supporting termites. They were especially numerous in the rear of the building on the north side of the women's pavilion and on the south side of the men's pavilion, but they were found scatteringly in other places. It was not possible to determine from what

direction or directions they were spreading toward the building. In fact, the condition seemed rather to be that the ground was pretty well infested in almost every direction.

The probability is that there were, and are, pieces of board and other bits of wood scattered through the ground here and there over much of the area, since a good deal of it represents a fill made by the contractors in grading, after the hospital was built. Odd pieces of board and other bits of wood were buried in the process of grading.

Very large numbers of termites were disclosed by the traps in the area back of the root cellar (Fig. 3, L.). A large, flat board was placed on the ground here. This was turned over every day and the termites found were killed with boiling water. Thousands were destroyed. By using boiling water instead of Phinotas oil at this place the ground was not rendered unsuitable for the termites and they continued to come to the board trap.

It was felt that there was danger that the termites would construct galleries over the concrete and stone posts to the lattice work or flooring of the porches. Also, at the inclines (Fig. 3, A. A.), where concrete had been substituted for the wooden parts next to the ground, it was feared that galleries might be constructed to reach the wood. In order to forestall this, a band of tree tanglefoot was applied around the brick posts of the porches beneath the lattice work and a similar band around the concrete supports for the entrance In other places where it was feared that galleries might be constructed, tanglefoot was used in the same fashion. In no case were termite galleries discovered. The bands were kept fresh by combing out at frequent intervals.

Three seasons have now elapsed since the control work was begun. The closest possible watch has been kept for termites within the administration

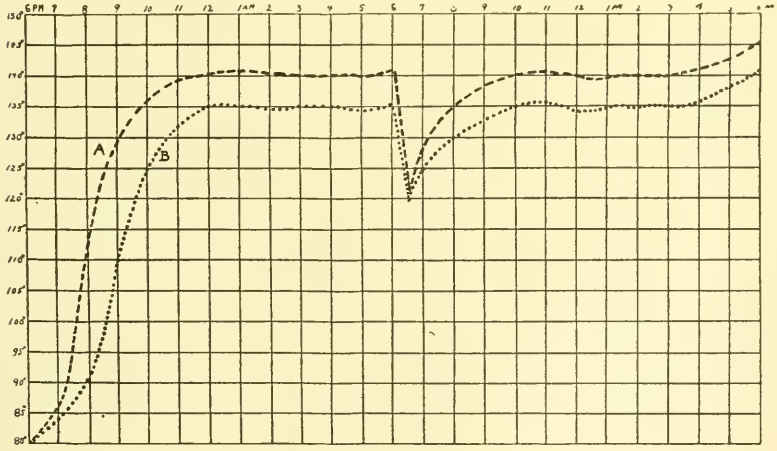


FIG. 5. Graph of temperature records. The dash line A is the average of thermometers lowered through floor. The dotted line B is the thermograph record.

building and other parts of the hospital throughout that period, but none have been discovered within. The numbers recovered outside of the building have diminished.

During the last year, work has been in progress on still another wing south of the men's pavilion and connected to it by corridors. This new wing is located where the frame house and barn stood. Thorough precautions were taken to avoid permitting termites to get a start in the new wing. It will be noted that this wing is built in part where large numbers were found in the barn cellars.

The basement of the new wing was constructed with special care to render it proof against entrance by termites. While the building was being constructed, an attempt was made to keep boards, beams and other structural material elevated on skids and protected by tanglefoot or by Phinotas oil. The new building is now practically completed and no termite has been discovered within it.